CALIFORNIA
ENERGY
COMMISSION

# Evaluation of the Benefits to California Electric Ratepayers from the Public Interest Energy Research Program, 1998-2002

CONSULTANT REPORT

MAY 2003
500-03-024F

Gray Davis, *Governor*

# CALIFORNIA ENERGY COMMISSION

***Prepared By:***

Gerald D. Pine, Consultant
Marshall, Illinois

Contract No. 500-01-007

***Prepared For:***

Mike Magaletti,
***Project Manager***

Terry Surles,
***PIER Program Manager***

Robert L. Therkelsen,
***Executive Director***

# Legal Notice

## Acknowledgments

Many PIER staff members and contractors gave generously of their time in providing information about the PIER RD&D program and its products, without which this report could not have been completed. The author thanks all of them even though they number too many for individual mention. Particular thanks go to Mike Magaletti, Alec Jenkins, and Terry Surles, who provided oversight and guidance throughout the effort and who made sure that I had the resources and support to get the job done.

# Table of Contents

# Tables

# Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

What follows is the final report for the *Support for PIER Program Evaluation and Benefits Analysis,* Contract Number 500-01-007. The report is entitled *Evaluation of the Benefits to California Electric Ratepayers from the Public Interest Energy Research Program, 1998-2002.* This project contributes to the overall PIER Program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

# Executive Summary

This paper contains a summary of an evaluation of RD&D results of the Public Interest Energy Research (PIER) program that have been placed into commercial use through early 2003. The PIER program began in 1998 and completed its fifth year of operation in 2002. Commercial use of twenty products was documented, and benefits to product users were quantified for 16 of the 20 products using an approach originally developed and used by the Gas Research Institute (now Gas Technology Institute). Salient findings and observations include the following:

1. Quantifiable benefits to product users for the twenty PIER RD&D products placed into commercial use between 1998 and the end of 2002 are estimated to be between $200 million and $525 million. A number of factors cause the market penetration and the user benefits of a product to be uncertain. The products have only recently become commercially available and product sales are based solely on forecasts. These forecasts may prove too high or too low, and the market penetration may occur more slowly or more rapidly than expected. In addition, assumptions must be made about how the products are used (intensity of use, applications characteristics, etc). The ranges shown for the benefits represent the judgment of the evaluators about the uncertainties in these and other factors. Even at the low end of the range, however, the benefits are significant in comparison to the estimated total contract disbursements of $125 million to operate the PIER program from 1998 through 2002.

2. In addition to direct benefits to product users, many products will also create significant, measurable indirect benefits for other parties. For example, some products will create new manufacturing or service activities in California that will employ Californians. Lower cost products will compete with existing higher cost products and induce price reductions to the benefit of users of the competing products. Products that result in reduced emissions benefit the public by helping to provide a cleaner, healthier environment and reduced levels of morbidity and mortality. Quantitative estimation of these indirect benefits was beyond the scope of this evaluation, but we acknowledge that their inclusion would increase the benefits of the PIER program from our estimates.

# Abstract

This report summarizes an evaluation of the benefits to California electric ratepayers as a result of PIER Program activities undertaken between 1998 and 2002. Twenty products were identified that have been placed into commercial service through early 2003. These products are expected to produce net life cycle benefits valued at $200-525 million as a result of sales projected during the first five years of commercial use. Based on an estimated $125 million in PIER Program disbursements between 1998 and 2002, PIER is creating $2-4 in ratepayer benefits for every dollar spent on the program. Additional benefits, not quantified in this evaluation, will also accrue to Californians. These benefits include increased jobs and economic activity from the manufacture of several of the products in California, a healthier environment as a result of emissions reductions associated with the use of some products, and reduced strain on the electricity system as a result of products that reduce electricity consumption.

## 1.0 Introduction

The Public Interest Energy Research (PIER) program is an electricity-related research program paid for by a surcharge on electricity to electric customers of investor-owned utilities in the State of California. The program was established in 1997, and the California Energy Commission (Commission) was given management responsibilities in 1998. A number of ongoing California electric utility RD&D programs were folded into the PIER program and Commission staff also was given management responsibility for the duration of these programs. The Legislature established a requirement for an Independent Review Panel to review the public value of the PIER program and to make recommendations to the Legislature and to the Governor. This panel published a report in March 2001 summarizing its findings[1]. The Panel attempted to evaluate the public benefits of PIER programs as part of its review, but concluded that

> "In a broad sense these projects were strategic in nature and involved the public interest, but their public value is yet to be determined. A number of the projects had the potential to reduce energy demand, improve system reliability, or address environmental issues that would not otherwise be funded. However, the potential and probability of future market utilization was not always apparent nor were there clear links to other state-funded market transformation programs[2]."

Further, the Panel recommended that the next legislatively mandated independent review "assess the public value of completed PIER projects awarded during 1999 and 2000[3]." Senate Bill 1038, which authorized continuation of PIER funding through 2006, requires that each year the Commission submit to the Legislature an annual report. "This report shall set forth the actual costs of programs or projects funded by the commission, the results achieved, and how the actual costs and results compare to the expected costs and benefits[4]." The evaluation presented here represents an initial foray into PIER RD&D product evaluation.

An approach developed and used by the Gas Research Institute (now Gas Technology Institute) has been used to evaluate a set of PIER near-term RD&D results judged to have potentially high impacts in their target markets. The benefits are based on projected sales or applications of these products during their first five years of

---

[1] "California Public Interest Energy Research: Independent PIER Review Panel Final Report," March 2001, California Council on Science and Technology.

[2] Ibid, p.16.

[3] Ibid, p. 19.

[4] California Senate Bill No. 1038. Ch. 515, Section 7: California Public Resources Code Section 25620.8.

commercial availability. The benefits are based on side-by-side comparisons of the PIER products and their likely competitors in the market, and a net present value is calculated for the cash flow stream over the economic lifetimes of the products sold during the initial five years. The present values are generally based on reduced energy costs, reduced operating costs, or avoided or deferred capital expenditures.

## 2.0 Technologies Evaluated

### 2.1. Residential and Commercial Buildings End Use Energy Efficiency Program Area

#### 2.1.1. Berkeley Lamp

Lighting is a major electricity load in California, accounting for 22% of California's electricity consumption, and it also adds to the summer air conditioning load. Compact fluorescent lamps (CFLs) are available to replace incandescent bulbs in lamps and other applications, and overhead fluorescent bulbs have become a mainstay in offices and other commercial buildings. However, CFLs have not proven adequate replacements for indirect room lighting applications that are increasingly being met by halogen torchieres in residences. Lighting energy consumption in commercial buildings could be further reduced if a suitable task light substitute were available to substitute for overhead fluorescents. Lawrence Berkeley National Laboratory, with funding from PIER and from DOE, designed a new lamp with these needs in mind. The Berkeley Lamp, which is being manufactured and marketed by the Light Corporation, uses two compact fluorescent lamps (CFLs) in a flexible configuration designed to provide surface task lighting, indirect overhead lighting, or both. The lamp is designed especially to meet the needs of the modern office environment with computers. In a residential environment the lamp can replace a standard incandescent table lamp for reading or other needs requiring a direct light source, and it is also a very capable replacement for a dimmable halogen torchiere where indirect room or background lighting is desired. The lamp is available today at a slight cost premium over similar lamps, but the cost is expected to drop after the company gains some experience with the market.

#### 2.1.2. Commercial Kitchen Ventilation

Kitchen hoods are designed to remove grease, water vapor, combustion gases, and other gases emitted during food preparation activities. Design hood exhaust volumes and airflow velocities are based on expected equipment operation. In practice, however, improper installation, interactions with HVAC system airflows, and changes in kitchen configuration can all reduce the effectiveness of hood performance. One significant factor that affects hood performance is the pattern of airflows from people movement, HVAC system ducts and outlets, and portable fans and other air moving devices. One element that the kitchen designer can control is the geometry of air ducts and outlets for HVAC and makeup air systems. Interference between duct outlet air flow and hood airflow can cause spillover of hood exhaust into the room. To counteract this spillover effect, hood flow velocities (and volume) are typically increased until spillover is reduced to an acceptable level. PIER has supported research to develop an understanding of these interactions between HVAC airflow and hood airflow and to develop design guidelines to minimize these interactions. Researchers have found that the hood air velocity (and exhaust volume) can be reduced by up to 40% in typical applications without loss in hood effectiveness. Makeup air is often conditioned, so a reduction of required makeup air will reduce energy used for heating or cooling and in fan power required to deliver the conditioned air.

### 2.1.3. Particulate Emissions Measurement Protocol and Technique for Unhooded Commercial Restaurant Appliances

The PG&E Food Service Technology Center, with PIER funding, developed a test method and a measurement protocol for measuring particulate matter (PM) emissions from commercial cooking appliances. Emissions from cooking appliances are of concern to equipment vendors and restaurant owners for at least three reasons. (1) PM emissions are an indoor air quality issue. (2) The South Coast Air Quality Management District (SCAQMD) in California controls PM and reactive hydrocarbon emissions from some restaurant appliances now, and SCAQMD and other air quality districts in California are expected to expand such controls in the future. (3) Hoods are a major energy user in restaurants. If a hood can be eliminated, the restaurant operator will realize significant savings in electricity for fan power and for operation of the HVAC system and may also realize savings in the initial costs of HVAC equipment, ducting, and the hood. Standard, recognized measurement protocols and techniques are important to equipment manufacturers and vendors in obtaining certification that their equipment meets any current or future air quality regulations without the use of a hood. Although neither ASHRAE nor UL has officially accepted this test as a standard, acceptance is expected after the normal review procedures have been completed. At this time, UL recognizes the tests as a UL Witness Test.

### 2.1.4. Revised Residential Framing Factors

California's Title 24 Building Energy Efficiency Standard prescribes minimum design U values (a measure of heat conductivity) for thermal design of new residential structures in California. Compliance with the Title 24 requirements may be demonstrated either by the use of detailed energy analyses of the actual structure or by using default values for certain key parameters and using insulation, fenestration, and other components in a manner consistent with the default parameter values. One such key default parameter is the framing factor, a measure of the fraction of the building wall area occupied by the framing structural components required for doors and windows. The amount of framing is important because it consumes wall volume that otherwise would normally contain insulation and because it has a higher thermal conductivity that the insulation it displaces. If the default values for the framing factors are accurate, application of the Title 24 requirements will result in sufficient additional wall insulation to overcome the higher conductivity of the framing. If the values are inaccurate, the building will either use more energy than intended or the building will be over-designed and more costly to construct than necessary to meet the standard. When Title 24 was first written, there were no established estimates of framing factors for residential structures in California, and code developers had to rely strictly on expert estimates for the default framing factor values. As part of a planned 2005 update of Title 24, PIER hired Enermodal Engineering to survey new residential structures in California in order to replace the original framing factor estimates with empirical data. The survey showed that the original framing factor defaults used in Title 24 had been too low, and survey values will replace the old values in the 2005 update. The result of this change will be that added insulation or other design changes will be required to satisfy Title 24 requirements, and the actual building energy use will be reduced.

### 2.1.5. HVAC Duct Sealing Requirements for Small Commercial Buildings

Air leaks from ductwork used to distribute conditioned air in small commercial buildings have been found to be 30% or more of duct flow in typical buildings. As ducts are located in unconditioned spaces for over 60% of small commercial buildings, this leads to the loss of conditioned air and wasted energy. Thus, elimination of duct leakage can reduce cooling loads by up to 20%. Because cooling is a major electricity load in commercial buildings and because cooling loads tend to be coincident with peak electricity demand, proper duct sealing will also reduce the peak electricity demand in these buildings. A duct sealing technique based on the use of an aerosol spray applied inside the ductwork was shown to be very effective in sealing leaks in an R&D project at the Lawrence Berkeley National Laboratory (LBNL). The new sealing technique has been demonstrated to reduce duct leakage to below 10%. Largely on the basis of the new aerosol sealing technique's success in reducing leakage, a new prescriptive measure for sealing ducts in light commercial buildings is included in the 2005 update of Title 24. These requirements apply for new buildings and for existing buildings upon replacement of the HVAC system or duct system. Aeroseal, a division of Carrier, has also introduced the new aerosol duct sealing technique as a commercial service to building owners.

### 2.1.6. Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings

Approximately 50-75% of new retail construction makes use of dropped ceiling systems (T-bar and acoustical tile). Acoustic ceiling / lighting design affects fire protection, seismic safety, lighting, day lighting, insulation, mechanical systems and acoustics. At least 60% of ceiling area is directly below a roof and therefore, how well building components and energy consuming systems are integrated to configure the ceiling system is a serious issue that impacts the resultant building energy use. Lay-in insulation is often used with the dropped ceilings. Although there is no inherent reason that lay-in insulation cannot perform well, remodeling of spaces (duct work, new lighting, wiring, etc.) is common, and lay-in insulation is frequently disturbed and not reinstalled properly after the remodeling. This leads to voids in the insulation. A telephone survey and follow-up visits of a sample of buildings funded by PIER showed that voids in the insulation in existing buildings ranged from 7% to 95%. An analysis undertaken as a part of the same study showed that insulation attached to the underside of the roof deck is cost effective based on improved efficiency except when the average height of the space between the ceiling and the roof is greater than 12 feet. Consequently, a proposal was made and accepted by the Commission to change the language of Title 24 to require that the insulation be in direct contact with the roof deck except when the ceiling to roof space exceeds 12 feet. This change, which will go into effect in 2005, will reduce the energy use and fuel costs in the affected non-residential buildings.

### 2.1.7. Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings

The use of skylights has been found to be an effective method of reducing electricity use in low-rise buildings by California electric utilities through their efficiency programs. As a result, a change in Title 24, effective in 2005, was proposed and accepted to mandate the use of skylights and automatic controls in new low-rise buildings with enclosed spaces of 25,000 square feet or more directly under a roof. Buildings with special requirements, such as museums, movie theaters, and refrigerated warehouses will be exempted from the requirement. Only about 26% of commercial buildings use skylights today, so the potential for savings is large. Energy use simulations indicate that the adoption of this measure will create net savings of $1.00 or more per square foot of day lit space for building owners/operators.

### 2.1.8. Goettl Comfortquest Gas Heat Pump

Goettl Air Conditioning, Inc. introduced a line of natural gas-fired heat pumps for the commercial buildings sector as a result of a research effort funded in part by PIER. The heat pumps have a natural gas engine that drives a compressor and use far less electricity than an equivalent sized electric heat pump. Sizes from 15 tons to 30 tons are available, and the product has achieved some success in California in markets where electrical capacity available to a building is constrained and would be very costly to augment. This product has a limited market potential in a future with plentiful electricity and relatively high gas prices, but its value and market potential would both increase under conditions of a plentiful gas supply and constrained electricity supply.

### 2.1.9. Real-Time Energy Management and Control Systems

In 1998 and 1999, a PIER-funded RD&D effort performed by the LBNL was undertaken to commission and operate a prototype Information Monitoring and Diagnostic System (IMDS) in a 100,000 sq. ft. office building in San Francisco. For this project, the system deployed consisted of 57 measurements and 28 calculated points that monitored the performance of the building system and outdoor weather. LBNL staff interacted frequently with the building operators to develop useful analyses and displays of the data that would be useful. Over the one-year test period, the IMDS system identified a series of critical control problems that were previously unknown, implemented controls automation that reduced the number of system operator labor hours required (worth about $20,000/year), and recommended a series of actions that should save approximately $30,000/year in energy costs if implemented. Although the PIER project did not directly result in a commercial product, the information developed has supported the development and marketing of at least two new commercial product suites. Silicon Energy Corp. (since acquired by Itron, Inc.) incorporated some of the successful IMDS displays into its EEM Suite™ of products, which allow real-time energy management and control of a geographically dispersed group of buildings through Internet links. Another company, PowerNet Software, offers the PowerVisor™, which was developed independently of the IMDS project, but which has used the IMDS results in its marketing literature to help to establish the economic case for on-line, intelligent building diagnostics.

## 2.2. Environmentally Preferred Advanced Generation Program Area

### 2.2.1. Catalytica Xonon™ Catalytic Burner

California has long struggled to improve the quality of its air, particularly in developed areas where problems are most acute. $NO_x$, a major contributor to urban smog and a by-product of high-temperature combustion of fossil fuels, is one emission that is tightly controlled. Some air quality management districts in California restrict emissions of $NO_x$ from new sources to no more than 2 parts per million. The best existing small gas turbines (0-10 MW) can reduce $NO_x$ emissions only to about 15 ppm. Lower emissions can be obtained by adding exhaust gas cleanup systems such as SCR or SNCR, but they are very expensive to build and operate, they reduce the electricity generated by the turbine, and they reduce system reliability. Consequently, few new small gas turbines are currently being added where such emissions restrictions exist. PIER has sponsored RD&D by Catalytica Energy Systems, who have adapted their preexisting Xonon™ burners for use in small gas turbines. This burner produces $NO_x$ emissions of approximately 2-ppm at a fraction of the cost of an exhaust cleanup system. In addition, turbine performance will be maintained at the same level as with other burners, and the reliability problems associated with an exhaust cleanup system will be avoided.

## 2.3. Energy Systems Integration Program Area

### 2.3.1. DG Interconnect Hardware

The San Diego Gas and Electric Company, with support from the PIER program and from EPRI, has demonstrated the viability of an inexpensive, Rule 21 compliant, solid state interconnection system to control grid-connected distributed generation systems. The interconnection hardware is offered commercially by EnCorp, Inc. as the *enpower™-GPC*. The EnCorp system satisfied all utility interconnection requirements at a cost that was only 50-95% that of a conventional interconnection system. The enpower-GPC will make it easier and cheaper for small-to-medium-sized businesses, such as grocery stores or office buildings, to connect standby generators in parallel to the electric grid to allow them to displace grid power during high-price periods.

### 2.3.2. Real-Time Monitoring and Dynamic Rating System For Overhead Transmission Lines

The most common factor limiting transmission current-carrying capacity is the clearance between the line and the ground. As the current flow in a line increases, all other things remaining equal, the resistive power losses cause heating of the line, which causes the wire to expand, which increases the sag between supporting towers. This sagging is increased by heating of the line by the sun, but is also reduced by cooling factors such as radiation of heat from the line and by convective cooling by the wind. The current is limited so that the clearance between the lowest point in the line and the ground will never be less than 21 feet. In lieu of actual observation of clearance of a line, conservative limitations are applied for a line to ensure compliance. For much of year, the current in the line could be increased well above the above current limitations without violating the 21-foot clearance. PIER has completed projects with San Diego Gas and Electric and with the California Independent System Operator (ISO) to develop and test real-time monitoring and dynamic rating systems to replace the more conservative static ratings. The San Diego Gas and Electric Company project showed that an increase of 10-15% in current capacity, and often more, could be obtained for some lines within the SDG&E system. The California ISO project has applied monitoring techniques to PG&E Path 15, which is a major bottleneck that limits power transfer between Southern and Northern California. Although the commercial experience with these monitoring systems is not yet sufficient to make a quantitative estimate of the benefits, it is clear that these systems can and will create significant benefits in future years as the capacity of existing transmission lines becomes more strained.

### 2.3.3. Interconnection Standards for Small Distributed Generators

Increasing numbers of electric utilities and non-utility entities have determined that they could benefit by constructing on-site electrical generation equipment to meet special facility or utility needs, to back up utility electricity supply, or to generate electricity for sale and distribution through the utility grid. Each utility independently developed interconnection requirements and procedures for connecting independent generators to the grid. Consequently, the physical requirements of all utilities were similar, but the process of getting approval for interconnection was often quite different from utility to utility. These differences meant that both utilities and applicants had steep learning curves and were able to apply only a limited portion of the experience gained in one utility's service area to subsequent installations in other utility service areas. The PIER program has taken an active role in working with California electric utilities and the California Public Utilities Commission to develop a common set of simplified procedures for reviewing and approving an application for a grid-connected distributed generators. The first phase, FOCUS-I, applied only to cases where the DG unit is connected to the grid but does not supply power to the grid. A simplified review process was developed that allowed the DG applicant to bypass several stages of the previous review process if he met certain minimal requirements. To date, it appears that the primary benefits of the rules simplification have been savings in required utility and applicant staff time to complete the application and review processes. Subsequent phases, which will extend the process simplification to DG units that supply power to the grid, are expected to create significantly greater benefits by increasing the market for DG.

### 2.3.4. Improved Substation Seismic Design

As a result of major damage in power substations in large California earthquakes in the 1990's, utilities, manufacturers, and others have developed seismic qualification procedures for major substation components. However, because a wide variety of different methods and hardware are used to make electrical connections between the components, no procedure could quantitatively address connected equipment. Work undertaken by the Pacific Earthquake Engineering Research (PEER) Center, with funding support from PIER, has extended the component seismic qualification testing to include the effects of component interconnections in a typical substation configuration. The PEER substation seismic research area has resulted in improvements in component performance standards and qualification tests, new substation seismic performance models that include the effects of component interconnections, and demonstrations of acceptable seismic performance of specific components and configurations. These results have already saved money for PG&E and its customers through avoidance of unnecessary expenditures where existing equipment was demonstrated to have adequate seismic performance. In addition, improved performance by substitution of more rugged components has also reduced the expected cost of future earthquakes by reducing the expected damage.

### 2.3.5. Reduced Utility Building Seismic Vulnerability

The ability of utility buildings to survive potential earthquakes is an important consideration related to public and employee safety as well as the ability of the utility to maintain and/or quickly restore services after an earthquake. As a result of experience gained from past earthquakes, PG&E is actively evaluating the structural vulnerabilities of its existing buildings and identifying retrofits that are required to bring vulnerable buildings up to the desired seismic performance standards. If structural models are weak in their abilities to predict building performance under anticipated seismic conditions, engineers generally compensate for the model weakness by using a large design safety factor. Although the use of a larger safety factor is likely to result in an acceptable seismic performance and increase public and employee safety, the cost is almost certainly higher than necessary were building seismic performance better understood. PEER research has developed a number of improvements in building structural models for common utility building types to better predict the seismic performance of the buildings. In the case of one common type of building, improved models showed that approximately 100 common buildings with rigid walls and flexible timber diaphragms have a greater capacity for surviving earthquakes than previously thought, and costly retrofits to strengthen the roof/wall connections were not necessary. For another type of building, model improvements including the effects of wall-out-of-plane stiffness allowed a less costly retrofit than would have otherwise been necessary.

## 2.4. Renewable Energy Technologies Program Area

### 2.4.1. $NO_x$ Control in Biomass-Fueled Boilers with Natural Gas Cofiring

PIER funded an RD&D project with the Gas Technology Institute (GTI) to adapt technology for gas cofiring of biomass-fueled (wood waste) boilers to the California market and to confirm the benefits of the technology. The GTI project demonstrated that by using gas cofiring in the 5-15% gas range, power generation economics can be improved, a maximum capacity constraint resulting from $NO_x$ emissions regulations can be eliminated, and the response of the electrical output to changing peak loads can be significantly improved. $NO_x$, CO, and particulate emissions are significantly reduced by the use of gas cofiring. Operation of the boiler on gas only demonstrated that the boilers can be operated at lower outputs than they could operating on biomass alone, allowing generation of "house loads" alone as opposed to additional power that cannot be sold. In the test case in a 10 MW plant, output was reduced to 2.8 MW with 100% biomass fuel and to 1.5 MW burning 100% gas. This reduction in the standby fuel requirement significantly increases the efficiency for typical cases where the minimum demand is less than the higher biomass only minimum output. Capacity of the plant was limited to about 8.5 MW with no cofire by $NO_x$ emissions limits, but the full 10 MW nominal capacity was used without violating $NO_x$ constraints when a 13% gas cofiring level was used. The additional 1.5 MW is a valuable commodity to the plant operator at the times of peak system electricity load. Finally, a target ramp up rate for electricity output of 1 MW/hr was established as the requirement for the plant to participate in ancillary power markets. A rate of 10 MW/hr was achieved, easily exceeding the target rate.

### 2.4.2. PowerGuard® Solar Electric System for Flat Roofs

The Powerlight Corporation has introduced a photovoltaic system integrated into a roof tile for commercial buildings. The tiles consist of solar panels mounted on a base of Styrofoam® insulation (R-19). The tiles are easily interconnected, making it easy to tailor the power output to the needs of the building. Output is about 10 watts per square foot. The system includes an inverter and grid-connect hardware to allow the system to exchange power with the grid. This allows the system to export power to the grid when output of the PV system is greater than the building demand and to import grid power when PV supply is inadequate to meet building demand. The system benefits the building owner by saving on electricity costs and by selling excess electricity back to the grid (through net metering), but there are also additional benefits to building owners. The PV tiles shade the roof from solar insolation and shield it from the weather. Current installations are over existing roofs and have tiles mounted on a rack above the roof. These installations do not add to the roof insulation to reduce heat transfer through the roof, but installations in new buildings are expected to be able to substitute the PV tile for existing roofing materials, reducing the roofing material costs and at the same time adding to the roof insulation. This added insulation will reduce the winter heating load as well as the summer cooling load. It is also expected that the life of the protected roof will be longer than the life of an unprotected roof. As the PV system peak output is generally coincident with utility summer peak load, the PV system will benefit not only the building owner/operator, but also other utility customers by reducing the peak summer electric demand; hence, the cost of owning and operating high cost utility peak generation capacity.

## 2.5. Energy-Related Environmental Research Program Area

### 2.5.1. Low $NO_x$ FIR Burner for Gas Boiler

PIER co-funded a project by the Institute of Gas Technology (now Gas Technology Institute) to develop a forced internal recirculation (FIR) burner for use in natural gas boilers. Funding was also provided by DOE Office of Industrial Technologies and the Gas Research Institute (also now Gas Technology Institute). The new burner uses several techniques, including premixed stoichiometric combustion, internal recirculation of combustion products, and staged combustion with enhanced combustion uniformity to reduce both $NO_x$ and CO emissions without sacrificing efficiency. Tests of a 20 million Btu/hr FIR burner demonstrated that emissions of less than 9 vppm $NO_x$ and less than 40 vppm CO could be achieved over a 4:1 turndown ratio and with less than 3% excess air. Over 5000 hours of continuous operation were logged with this burner.

Based on this success, Detroit Stoker Company has prepared a commercial burner design that will be retrofitted to an existing 60 million Btu / hr watertube boiler at a Southern California site (Fullerton) calendar year 2003. Assuming that this test is successful as anticipated, Detroit Stoker will then test the burner in commonly used 50 to 100 million Btu / hr watertube boilers and will then offer boiler models with the burner in the 20 to 200 million Btu / hr range. Watertube boilers in this size range are commonly used in the paper, chemicals, petroleum refining, and steel industries.

## 2.6. Industrial, Agriculture, and Water End Use Energy Efficiency Program Area

### 2.6.1. Cast Metal Industry Electricity Consumption Study

The California Cast Metals Association, with funding from PIER, completed a study of the energy use by metal melting operations in California foundries. The study consisted of three parts. First, the Foundry Energy Survey was done to collect information and establish a profile of California metal melting operations. Second, energy usage and cost savings strategies were discussed, and technical recommendations given on metal melting energy usage and areas of potential reductions. Third, energy providers and energy management issues were identified. Recommendations were then given on interfacing with energy suppliers on rate structures and using energy management tools to reduce usage. As a result of this study a report has been published to supply timely information that foundries, die casters, and smelters that will enable them to reduce their electricity use.

### 2.6.2. Poultry Rinse Recycling

Two relatively scarce commodities in California are electricity and water. In addition, California has environmental regulations that are among the strongest in the United States. A recent PIER-funded RD&D project provided a means to reduce water and electricity consumption while reducing effluents into California's water system and saving money and increasing productivity for users of the technology. The PIER project demonstrated the use of a water recycling system for chilled rinse water used in poultry processing plants. Specifically, the recycling system replaced chlorination of chilled water and replacement of chilled water on a daily basis with the use of ozone to kill bacteria and hollow membrane filtration to remove foreign matter and to reduce opacity of the treated water to allowable levels. The U.S. Department of Agriculture and the Food and Drug Administration have now approved this technology for use as a wastewater treatment technology in other similar facilities.

## 3.0 Findings and Results

**Table 1. Benefits of PIER RD&D Products Commercialized Through 2002**

| Product Name | Year of First Use | Sales or Applications in first five years | Range of Benefits |
|---|---|---|---|
| **RESIDENTIAL AND COMMERCIAL BUILDINGS END USE ENERGY EFFICIENCY:** | | | |
| Berkeley Lamp | 2001 | 5,000 to 60,000 | $2 to $23 million |
| Commercial Kitchen Ventilation | 2007 | 2,000 to 10,000 restaurants | $14 to $71 million |
| Particulate Emissions Measurement for Unhooded Restaurant Appliances | 2001 | Not tracked | < $1 million |
| Revised Residential Framing Factors—Title 24 Update (2005) | 2005 | 100,000-300,000 homes | $2 to $6 million |
| Duct Sealing Requirements for Small Commercial HVAC Systems—Title 24 Update (2005) | 2005 | 75 to 250 million square feet | $40 to $120 million |
| Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings—Title 24 Update (2005) | 2005 | 18 to 30 million square feet | $60 to $100 million |
| Requirements for Skylight Use in Low-Rise Residential and Commercial Buildings—Title 24 Update (2005) | 2005 | 80 to 175 million square feet | $60 to $130 million |
| Goettl Comfortquest Gas Heat Pump | 2002 | <100 | < $1 million |
| Real-Time Energy Management and Control Systems | 2002 | Insufficient data | |
| **ENVIRONMENTALLY PREFERRED ADVANCED GENERATION:** | | | |
| Catalytica Xonon™ Burner | 2002 | 50 to 250 MW | $5 to $25 million |
| **ENERGY SYSTEMS INTEGRATION:** | | | |
| DG Interconnect Hardware | 2001 | Insufficient data | |
| Real-Time Monitoring and Dynamic Rating System For Overhead Transmission Lines | 2000 | Insufficient data | |
| Interconnection Standards for Small Distributed Generators | 2002 | 500 to 2,000 kW | $4 to $16 million |
| Improved Substation Seismic Design | 2002 | -- | $1 to $2 million |
| Reduced Utility Building Seismic Vulnerability | 2002 | 100 buildings | $15 to $20 million |
| **RENEWABLE ENERGY TECHNOLOGIES:** | | | |
| $NO_x$ Control in Biomass-Fueled Boilers with Natural Gas Cofiring | 2002 | 2 to 8 boilers | $1 to $4 million |
| PowerGuard® Solar Electric System for Flat Roofs | 2001 | 5 to 10 MW | $30 to $80 million (gross revenues) |
| **ENERGY-RELATED ENVIRONMENTAL RESEARCH:** | | | |
| Low $NO_x$ FIR Burner for Gas Boiler | 2002-03 | 5 to 15 boilers | < $1 million |
| **INDUSTRIAL, AGRICULTURE, AND WATER END USE ENERGY EFFICIENCY:** | | | |
| Cast Metal Industry Electricity Consumption Study | 2001 | 5-50% CA market | $1 to $5 million |
| Poultry Rinse Water Recycling | 2002 | 10% to 50% of market | $1 to $5 million |

## 4.0 Conclusions and Recommendations

This report is a summary of analysis of the benefits to users of twenty PIER RD&D results placed into commercial use by the end of 2002. Benefits of tangible PIER products (e.g., hardware or software) are calculated based on projected dollar savings compared to continued use of the products' most likely competitors. For products that provide information to users, the benefits are based on the economic impacts of changes in energy-related decisions that result from use of the information. The evaluation considers only benefits that will result from sales or applications of products during the first five years of commercial availability. It is assumed that improved products or new information will supplant these products after that time. Although only five years of sales or applications are included, benefits will accrue during the lifetimes of the products after they are installed. These benefits are included in the analysis. As the PIER products have just begun to enter the market, benefits are very uncertain and are expressed as a range to account for this uncertainty.

Estimated benefits range from $200 million to $525 million. These benefits are quite impressive compared to an estimated $125 million disbursed to pay for the first 5 years of the PIER program. Approximately $254 million had been encumbered through the end of 2002, but the portion of the encumbered funds that had not yet been disbursed will pay for RD&D that is yet to be done under existing contracts. This additional RD&D will generate additional PIER commercial RD&D successes. In addition, several additional results from completed PIER RD&D are expected to enter commercial use in the next few years without additional PIER funding.

The point of view taken in evaluating the product benefits is generally that of the product user in California. Only expenditures that must be undertaken by the users to implement the products are considered on the cost side. Manufacturer or vendor costs to manufacture and distribute the products are not included in the analysis. Nor are manufacturer or vendor profits included in the benefits analysis. These costs incurred and benefits realized by the manufacturers and vendors of the products have no direct bearing on the product user except as reflected in the product price, which is used as an input to our calculation.

Based on the experience of the evaluator, a few of the products will succeed to a greater extent than projected here, but several will lag in entering the market and will not succeed to the extent projected. Some will likely fail soon after their market entries. That expectation can be verified or refuted only after the products have been in the market for a time. A number of the products will require significant ongoing effort after research completion if potential impacts are to be realized. For tangible hardware products, product manufacturers and vendors, who stand to gain from the success of the products, will likely undertake this effort. For many of the information products, however, there is no such clear motivation to make sure the products are used. Examples include the Rule 21 efforts on interconnection standards and guidelines for distributed generators, the Residential Commissioning work, the Commercial Kitchen Ventilation Guidelines, and the Residential Framing Study. PIER, in recognition of this need, is increasing its efforts to support product deployment. Still other products will be found deficient in some regard and will require further R&D to correct these deficiencies.

In addition to the product user benefits that have been considered to date, additional benefits will accrue to other parties.  For example, products that reduce the peak demand for electricity will reduce the likelihood of shortages and will reduce the costs of electricity to all ratepayers by reducing the need for new construction (especially in the residential sector, where rates do not reflect time of use).  Other projects will reduce the use of water.  Benefits will accrue to other water users in the form of lower costs for water. Only benefits that accrue to electric ratepayers of the investor-owned utilities in California as a direct result of the effects on electricity-using activities are included in this analysis.

# Appendix:  Approach and Methodology

# Appendix: Approach and Methodology

The approach used for this evaluation is based on an approach used by the evaluator to quantify the benefits of RD&D products resulting from research programs of the Gas Research Institute (GRI). The GRI program was very similar in structure and product mix to the PIER program, and it is expected that the techniques should be generally applicable to PIER products. Although it is expected that additional types of benefits will be considered in future analyses, this initial study focuses primarily on direct economic benefits of PIER products to product users. The basic steps in the process are summarized below.

**For tangible commercial hardware or software products, the steps are:**

1. Identify products that have entered the market and verify that they are available for sale or distribution, that the manufacturer is committed to selling the product, and that the product is performing properly in user applications.
2. Compile a list of all products that have entered the market through early 2003.
3. Collect data that characterizes the product cost, performance, and features valued by users. The preferred sources of data are product vendors for cost information and data from users for performance and features information.
4. Identify the typical product that the new product is replacing and collect analogous cost and performance information for that product.
5. Estimate the economic lifetime of the new product.
6. Obtain fuel price and other general economic data to use in calculating dollar value of energy savings or consumption and to make other cost calculations (e.g., labor costs).
7. Develop a spreadsheet to calculate the annual dollar benefits that the product user receives by using the new product rather than the competing product. The calculation covers each year of the product lifetime and includes all differences in initial product costs, fuel costs, and operating and maintenance costs. Sales by year are explicitly included in the spreadsheet model. Calculations are based on constant (excluding inflation) dollars, and a net present value of the stream of annual incremental costs or savings is calculated based on a 5% discount rate.
8. Collect data on actual product sales or distribution to date and project sales for the next five years. Product vendors or manufacturers are the preferred source of this data. Evaluate the credibility of this data and adjust based on past experience with similar products.
9. Insert the product sales forecast into the spreadsheet model.

10. Estimate a range of benefits for each product based on the spreadsheet analyses and augmented by use of uncertainties associated with future product sales and performance.

11. Sum the ranges of the present values of benefits for all products evaluated and compare the resulting range to the present value of PIER disbursements over the past 5 years. This is an overall organizational benefit-to-cost ratio that can be used to provide a measure of benefits provided by the organization over a 5-year period. [This step applies only after all products have been evaluated.]

**For RD&D with a primary product in the form of information rather than a tangible commercial product, the above approach is modified as follows:**

- The use of the information by the user is evaluated to identify changes in decisions or in practices that result from using the new information. For example, a customer may change his purchase decisions or regulations, codes, or standards may be altered.
- The implications of the changes in decisions or practices are studied to identify economic consequences to the product users. Both annual economic consequences and the duration of the consequences are estimated.
- Annual economic savings are calculated for a typical user based on the economic consequences of the changed decisions.
- Rather than collecting vendor sales data estimates must be derived of the past and forecasted use of the information (number of uses per year).
- Calculations proceed as in the case of the tangible product. The number of annual uses of the information replaces the sales or applications estimates in step 8. The annual economic consequences of the changed decisions replace the benefits calculated in step 7. The duration of the economic consequences replaces the economic lifetime of the product used in step 7.